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ALBUMINURIA AND NEPHRITIS IN DAIRY COWS

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Albuminuria and Nephritis in Dairy Cows

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INTRODUCTION

This is a study of the occurrence of albuminuria and nephritis in the Kentucky Agricultural Experiment Station dairy herd from October, 1930, to April, 1937. This herd is a good subject for such an investigation. All the animals considered in this study were bred and reared on the farm, the last purchased female having been added to the herd in 1925. The health of the herd has been under the close supervision of the members of the staff of the Department of Animal Pathology since September, 1928. A record of all of their work with the herd has been kept in a health book. Except cows numbers E 29, E 41, E 53, E 55, E 68 and E 70, the health record of all animals considered is complete from birth. The herd has been free from tuberculosis since 1920 and the eradication of Bang's disease, which was started in 1928, was completed in January, 1933. Since that date all suspected animals have been immediately removed from the herd.

During the period under consideration this herd has averaged 62 cows and heifers of breeding age. The distribution of these animals according to breed is shown in Table 1.

Table 1. Number of cows and heifers of breeding age in the herd, 1930 to 1936, inclusive. Distributed according to breed.

Year	Jersey	Holstein	Guernsey	Total
1930	42	15	10	67
1931	41	15	8	64
1932	38	20	8	66
1933	42	21	3	66
1934	39	17	2	58
1935	42	15		57
1936	40	18		58
Total cow years	284	121	31	436
Percent of total cow years	65.1	27.8	7.1	

Except the milking herd, the three breeds were maintained exactly alike. All cows and heifers had access to typical bluegrass pasture from about the first of April to the middle of November. Cows in milk always received grain in proportion to their production. The grain mixtures thruout the entire period were as follows:

On fresh green pasture	4 parts corn 2 parts wheat bran 1 part cottonseed meal
On older pasture and dry hay	3 parts corn 2 parts wheat bran 1 part cottonseed meal

Two percent steamed bone meal was added to each of these mixtures.

The cows all calved in the same stalls and the calves were housed in the same barn. It was not unusual to let calves of two breeds occupy the same stall. The heifers were fed and housed exactly alike. While many of the sick animals were segregated, this was not done with those that showed albuminuria or symptoms of nephritis.

The early examinations of the urine were made by Dr. Daniel J. Healy who carried on this work from 1930 to the time of his death in November, 1934. His work may be divided into two periods. The first extends from October, 1930, thru January, 1931. Thirty-seven cows and heifers were examined. Some of the animals which showed albuminuria were followed up with frequent examinations after this period. It is interesting to note that these early examinations were made partly because of the insistence of the superintendent of the dairy herd that "some of the cows had bad kidneys."

The second period began in April, 1932. The urine from all heifers under one year of age, at this date, was examined monthly for a period varying from eight months to two years. These examinations were part of the work done on a project which was instituted to study reasons for delayed conception and sterility in dairy heifers.

No examinations were made from the time of Dr. Healy's death until April, 1935, when the work was taken up by the senior author.

Since then urine samples have been examined as often as practicable.

Since the start of the work, 1545 samples of urine from 156 animals have been examined. No effort was made to select these samples with respect to breed. Sixty-six percent of the animals examined were Jerseys and 29 percent were Holsteins. This distribution corresponds very closely with the proportions of these two breeds in the herd during this period, shown in Table 1. During the early part of the work, no effort was made to examine every cow but since 1935 the urine from all females in the herd has been examined at least four times a year.

METHODS

Most of the examinations reported by Dr. Healy include values for pH, specific gravity, ammonia nitrogen, calcium, and sulfur. The senior author has made determinations for various constituents of the urine. Because of the desire to present this work largely from a pathological and clinical view point these data will be considered in a later publication.

Dr. Healy determined the albumin in the urine by the heat and acetic acid coagulation. His results are reported as "Trace" "Present" and "Marked." Since April, 1935, a quantitative method described by Kingsbury, Clark, Williams, and Post (1) has been used in which the albumin is precipitated by a three percent solution of sulfosalicylic acid and the resulting cloudiness is compared with a set of permanent standards. The results are reported in milligrams per 100 cc of urine.

In the beginning most of the urine samples were collected by waiting for the cow to urinate. The urine was caught in a dipper which was fastened to a stick 6 to 8 feet long. This arrangement made it possible to reach out and catch samples which might otherwise have been lost. Occasionally, because of lack of time, it was necessary to catheterize an animal.

During the last two years it was found possible to make most of the cows urinate rather quickly by the use of a method which was suggested by Smith and Little (2). This method is to rub with a blunt stick back and forth across the region immediately below the vulva.

Table 2. Occurrence of albuminuria in the Station herd. (N, test for

Cow No.	Breed	Date Born	1930	1931	1932	1933	1934	1935	1936
E 29*	Jer.	12/22/23	N	NNN NNN	XX				
E 41	Jer.	9/16/25	X	N— —					
E 53	Jer.	11/20/26	X						
E 55	Jer.	12/ 4/26	X	NN					
E 68*	Jer.	9/17/27	X	— —	— —	— —	— —	—XX XXX	XX
E 70	Guern.	12/16/27	X	XN—					
E 77	Jer.	5/26/28	X	XN—					
E 81	Jer.	7/ 4/28	X	— —X					
E 100	Jer.	2/ 4/29	X	N— —					
E 102	Jer.	2/24/29	X	N— — —					
E 127	Jer.	12/14/29	X	— — — —	—				
E 134	Jer.	1/22/30	X	— — — —	—				
E 135*	Jer.	2/ 1/30	X	— —	XX				
E 138*	Jer.	3/28/30	X	— — — —	— —	— —	— —	—N —X	
E 139	Hol.	4/13/30	X	— — — —	— —	— —	— —	—NN NNN	XNN NNN
E 140	Jer.	4/15/30	X	— — — X	— —	— —	— —	—NN NN	
E 142*	Jer.	5/31/30	—	—X— —X—	—X— —	— X—	—		
E 153	Jer.	11/12/30	X	X— — —	— —	— —	— —	— —	—
E 165*	Jer.	2/20/31		— —X	XXX XXX	— —	— —	—X XXX	X
E 167	Jer.	3/ 7/31		— —	—N XXX	N— —	— —	—	
E 173	Hol.	4/20/31		— —	—N NN X	XX— —	— —	—N NNN	N
E 176*	Jer.	5/25/31		— —	—N XXX	X— —	— —	— —X	XX
E 180	Guern.	7/ 3/31		—	—NN NXN	N—			
E 182	Hol.	7/13/31		—	—NN XNX	XN— —	— —	—N NNN	NNN NNN
E 186*	Jer.	8/ 3/31		—X	XXX XXX	X— —	— —	—N —X	X
E 187	Jer.	9/28/31		—	—NN XNX	N— —	— —	— —	—
E 192*	Jer.	12/15/31			—XX XXX	XXX XXX	— —	—X XX	
E 193*	Jer.	12/21/31			—XX NNN	NXX XXX	X— —	—X XXX	XXX
E 194	Jer.	1/20/32			XNX XXX	XXX XXN	— —	—N NNN	NNN NNN
E 197	Jer.	2/10/32			NN NNX	NXN XXN	NNN —	—N NNN	NNN NNN
E 199	Jer.	2/22/32			NX NXN	XNN XNN	NNX N		
E 200	Jer.	3/ 7/32			X NNN	NNN XN—	— —	—N NNN	NNX NNN
E 212	Jer.	9/12/32			N	NXX XXX	NNN NN—	—N NNN	NNN NNN
E 215*	Jer.	10/ 1/32			X	XXX XXX	XXX XX—	—	
E 218	Jer.	11/23/32			N	XXX XXX	XNN N—	— N NNN	NNN NNN
E 223	Crossbred	1/ 7/33				NXN XNN	XNN N—	—N— —	
E 235	Hol.	5/26/33				X	— X NNN	NN— —N—	— X NNN NNN
E 237	Jer.	6/13/33					— X NNN	NN— —N—	—N NNN NNN
E 238	Jer.	6/21/33					— X NNN	NN— —N—	—N NNN NN
E 242	Jer.	7/23/33					— X NNN	NN— —N—	— NNN NNN
E 243*	Jer.	7/26/33					— X XXX	XX— —XX	XXX XXX XXX
E 244	Jer.	8/ 3/33					— X NNN	NN— —NN	NNN NNN NNN
E 250	Jer.	8/21/33					—N NNN	NN— —NN	NNN NNX
E 252	Hol.	9/23/33					— X NNN	XN— —N—	— NNN NNN
E 256*	Jer.	11/22/33					X NXX	XX— —XX	XXX XXX XXX
E 271	Jer.	4/ 5/34					X NX—	—NX NNN	NNN NNN
E 272	Jer.	5/17/34					X NX—	— —	NN
E 279	Jer.	6/23/34					XX—	—N— —	NNN NNN
E 293	Jer.	10/14/34					—	—NX —	NXN NNN
E 326	Jer.	9/ 7/35						XN	NNN NXN
E 346	Jer.	2/11/36							XX NNN
E 367	Jer.	10/13/36							X

* Diagnosed as nephritis.

albumin negative; X, albumin found; —, not tested.)

Notes
Died Apr. 1, 1932.
Killed Aug. 31, 1931. No postmortem.
Died Nov. 25, 1930. Metritis. No postmortem notes regarding kidneys.
Sold to stock yards Feb. 18, 1931.
Killed June 6, 1936.
Sold to stock yards June 17, 1931.
Sold to stock yards June 17, 1931.
Died Dec. 9, 1931. Metritis. No postmortem notes regarding kidneys.
Died Nov. 11, 1931. Metritis. No postmortem notes regarding kidneys.
Sold June 17, 1932. Non breeder.
Died Apr. 1, 1933. Difficult parturition. No postmortem notes regarding kidneys.
Sold to stock yards June 7, 1933.
Died May 8, 1933.
Killed Oct. 31, 1935.
Still in herd. Apparently normal.
Killed Dec. 17, 1935. Non breeder. Urinary tract appeared normal.
Died Feb. 17, 1934.
Sold for slaughter Nov. 21, 1934. Mastitis. No postmortem.
Killed March 18, 1936.
Sold for breeder Apr. 12, 1935.
Sent to beef herd for nurse cow May 20, 1936.
Killed March 18, 1936.
Sold for slaughter June 7, 1933. Aborted.
Still in herd. Apparently normal.
Killed March 18, 1936. Suspicious to test for Bang's disease.
Killed Oct. 31. 1935. Non breeder.
Killed Oct. 31, 1935.
Killed June 13, 1935.
Still in herd. Apparently normal.
Killed Dec. 8, 1936. Unprofitable.
Sold Sept. 7, 1934. Non breeder.
Still in herd. Apparently normal.
Still in herd. Apparently normal.
Died April 6, 1935.
Still in herd. Apparently normal.
Sold Aug. 29, 1935.
Still in herd. Apparently normal.
Still in herd. Apparently normal.
Killed Nov. 6, 1936.
Still in herd. Apparently normal.
Still in herd.
Still in herd. Apparently normal.
Killed Nov. 3, 1936. Non breeder.
Still in herd. Apparently normal.
Kept at clinic for experimental purposes.
Still in herd. Apparently normal.
Died May 28, 1936. Septicemia following calving.
Still in herd. Apparently normal.
Still in herd. Apparently normal.
Still in herd.
Still in herd.
Still in herd.

The occurrence of albuminuria in the herd is summarized in Table 2. This table includes all animals which have shown albumin in the urine more than once. An X indicates that one or more samples of urine showed albumin during the space of time covered by the symbol. A period of negative examinations is covered by an N. A dash (—) indicates a period during which no urine was examined. All cases in which a definite diagnosis of nephritis was made are indicated by an asterisk (*). These nephritis cases are discussed in the text. The amount of albumin found in the urine is not stated in this table but will be given in the case reports which follow.

Besides these animals recorded in table 2, four Jersey and four Holstein calves have shown albuminuria for short periods during the past two years. In four of these cases the albuminuria was accompanied by scours and in the other four it could not be explained. They are all normal at present.

The following case reports present the symptoms which may be of significance in explaining the development of the kidney condition.

CASE REPORTS

E 29. Born December 22, 1923. This was the first cow in which a definite diagnosis of nephritis was made. The health record which was started in 1928 gives no indication that there was anything wrong with her urinary tract prior to February, 1932. Four examinations of her urine in November, 1930, and one on November 19, 1931, showed no albumin. She developed severe mastitis on February 19, 1932. A sample of urine obtained on March 1, 1932, was bloody and showed a marked albuminuria. She died on April 1, 1932. The postmortem record includes the following: "Mastitis and nephritis with abscessed pyelitis and cystitis and with granulations on the bladder mucosa. Cultures showed a non hemolytic streptococcus."

E 68. Born September 17, 1927. This cow never showed any symptoms of nephritis. She produced five normal calves between April, 1930, and March, 1935. Her butter-fat production exceeded 300 pounds for each of these five lactations. She was killed on June 13, 1936, because of failure to breed.

The examination of her urine was carried out in two periods. Each of five samples taken during October and November, 1930, showed a trace of albumin. Repeated examinations made between May, 1935, and the time of her death all showed albumin which varied in amount from 40 to 150 mgm per 100 cc. No sample was ever negative to tests for albumin.

The kidneys appeared only slightly enlarged; the right one weighed 22 ounces and the left one 23 ounces. The capsule, which was thicker than normal, peeled readily showing the surface of the cortex to be covered with numerous small reddened areas. The surface was also slightly granular and showed several small cysts. These changes were uniformly distributed over the surface of each kidney.

On section, the most marked change was the increased thickness of the cortex and the thinness of the medulla. The cortex was so much swollen that the fissures between some of the lobules were not apparent. Its color was yellowish brown with an occasional reddened area on the cut surface. These areas were found in the outer part of the cortex. The medullary tissue was normal in color but was somewhat atrophied. No changes were found in the calyces, the ureters or the bladder. A careful examination of both kidneys revealed no evidence of calculi. Cultures from the cortex and calyces of both kidneys were negative.

E 135. Born February 1, 1930. This heifer evidently suffered with nephritis from calfhood to the time of her death on May 8, 1932. She was badly bloated on September 9, 1930, when only 7 months of age. From this date on the health record contains numerous references to treatments for chronic indigestion. Examinations of her urine during November and December, 1930, and again in February and March, 1932, all showed more or less albumin. On two occasions the albumin in the urine was reported as "marked."

She was found dead in the pasture. The postmortem notes report that kidneys "showed chronic interstitial nephritis of long standing." No histological study nor cultures were made.

E 138. Born March 28, 1930. This cow was killed on October 31, 1935, because of chronic mastitis which was first noted in October, 1933. Altho she showed no symptoms indicating an involvement of the urinary tract, traces of albumin were found in her urine during November and December, 1930, and again during October, 1935. One examination of her urine on May 19, 1935, showed no albumin. The kidneys appeared normal in every way except that each weighed only fifteen ounces. The calyces, ureters and bladder showed no changes. These kidneys were not cultured.

The microscopic changes were less marked in these kidneys than in the other cases. The principal changes noted were a cellular infiltration into the glomeruli, connective tissue formation in a few of the glomerular capsules, cloudy swelling of the epithelium of the convoluted tubules, and a slight edema around the tubules in the pelvis. There were a few small areas of round cell infiltration into the interstitial tissues of the cortex. The epithelium over the pelvis was normal. Both kidneys were equally affected.

E 142. Born May 31, 1930. This cow was treated for chronic indigestion from October, 1931, to the time of her death. On July 11, 1933, it was necessary to cut her vagina in order to deliver a calf. It was noted on October 31, 1933, that she was urinating frequently. A rectal examination showed her bladder to be very much enlarged and the wall thickened. She was treated for cystitis

by irrigating the bladder with disinfectants, from November 10, 1933, to January 4, 1934. Her urine was negative for albumin in October, 1931, but showed albumin in February and March, 1932, and again in August, 1933. She died on February 17, 1934. The postmortem report contains the following statement regarding the urinary tract: "Purulent nephritis, right kidney enlarged four times and filled with fistulous tracts. Cystitis." The kidneys were not cultured and no sections were made.

E 165. Born February 20, 1931. The clinical record is given in Table 3.

Table 3. Observations on Cow E 165.

Examination of Urine		Health Record	
Date	Albumin	Date*	Notes
1931		1931	
Oct. 6	None	Oct. 11	Off feed, treated for indigestion.
" 9	Present		
" 21	Marked	" 12	Treated for indigestion.
" 22	Present	" 18	Still off feed. She strains to urinate.
1932		" 21	Treated for indigestion.
Apr. 12	"	1932	
May 16	"	May 23	Bloated. Treated for indigestion.
June 14	None		
July 19	Trace	1933	
Sept. 15	"	July 2	Gave birth to dead 273-day calf.
Oct. 17	Present		
Nov. 14	"	1934	
Dec. 13	None	July 29	Normal parturition.
		1935	
1935		Jan. 10	Indigestion.
May 17	5 mg % **	Apr. 7	Indigestion. Slight attack of mastitis.
June 19	None		
Dec. 10	10 mg %	July 6	Normal parturition.
		Aug. 6	Treated for indigestion.
1936		1936	
Feb. 14	None	Mch. 10	Pregnant from 9/24/35 breeding.
Mch. 3	"		
" 16	50 mg %	" 18	Killed because unprofitable producer.

* In order to conserve space the dates under "Health Record" have been condensed so that they do not correspond with the dates under "Examination of Urine."

** Meaning 5 milligrams in 100 cubic centimeters.

The kidneys appeared normal on external examination, except that each weighed 15 ounces. The cut surface showed the medulla to be somewhat thickened and darker than normal. The ureters and bladder appeared normal. Both kidneys showed *Escherichia coli* in the cultures. The cultures from the ureters were negative.

The most noticeable changes in these kidneys was a distension of the tubules in the medulla. This was more marked in the pelvis where the distension had

resulted in the formation of small cysts. The cortex showed evidence of a glomerulonephritis. Many of the glomeruli were filled with round cells and were swollen so that they completely filled the capsule. All the tubular epithelium in the cortex showed a cloudy swelling.

The accompanying graph shows the production record of E 165 by weeks for three successive lactations. This record is fairly typical of the production

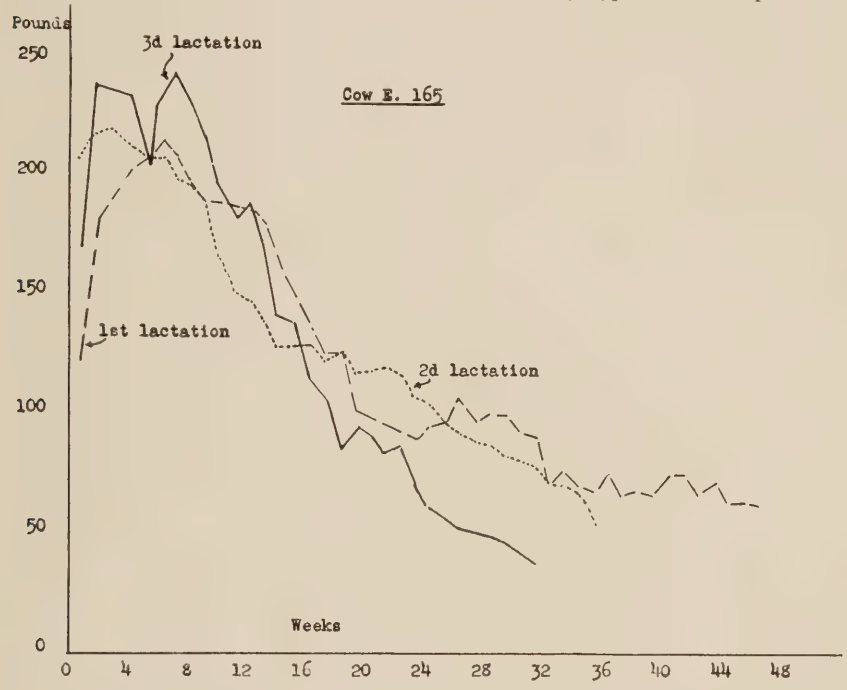

Figure 1. Production of milk, cow E 165.

made by the nephritis cases. While the weekly fluctuation is not so marked as in the case of E 243, which is discussed later, the failure to show characteristic increase in production due to advancing age should be noted.

E 176. Born May 25, 1931. The clinical record is given in Table 4.

Postmortem. Both kidneys very much enlarged; the right one weighed 36 ounces and the left one 48 ounces. The capsule was adherent. The bladder wall was very much thickened, with patches of exudate hanging to mucous membrane. Ureters enlarged to about twice normal size. Calyces of the kidneys contained a considerable amount of exudate and phosphatic material. The hemorrhage was confined to the bladder. Cultures from both ureters and kidneys showed a nonhemolytic streptococcus with an occasional colony of staphylococcus.

The histological examination of the kidneys showed large areas of fibrosis and round-cell infiltration extending from the capsule well down into the me-

dulla. Most of the glomeruli within these areas were fibrosed. Practically all those outside these areas had either undergone a pressure atrophy or were infiltrated with round cells. The glomerular capsules showed a thickening due to connective tissue formation. All the tubules were distended. In many of these tubules, especially in the medulla, the epithelium was completely sloughed off the basement membrane. There was considerable connective tissue formation around these tubules.

Table 4. Observations on Cow E 176.

Examination of Urine		Health Record	
Date	Albumin	Date*	Notes
1932		1932	
Apr. 12	Negative	Nov. 21	Treated for indigestion.
May 16	"	Dec. 1	Grunting, would not eat.
June 14	"	1933	
July 19	Trace	Aug. 19	Gave birth to normal calf. Difficult parturition. Necessary to cut vagina.
Sept. 15	"		
Oct. 17	"		
Nov. 14	Negative	1934	
Dec. 13	Trace	June 12 to 23	Mastitis.
1933		July 26	Normal parturition.
Feb. 20	"	1935	
		Mch. 28 to Apr. 24	Mastitis.
1935			
May 15	Negative	July 7	Normal parturition, followed by metritis.
Nov. 13	100 mg %		
" 14	70 " "	Sept. 4	Indigestion.
" 16	100 " "	Sept. 6	Mastitis.
" 19	40 " "	Nov. 11	Mastitis. Removed to clinic following this attack because udder practically ruined.
1936			
Feb. 17	100 " "		
" 24	100 " "		
Mch. 11	30 " "	Nov. 20	Losing in condition.
		1936	
		Feb. 16	Catheterized and obtained sample of bloody urine containing shreds of fibrin and fragments of phosphatic material.
		Feb. 18	Still passing fibrin and phosphatic material in urine.
		Mch. 11	Urine practically free from blood.
		" 16	Bloody cystitis.
		" 18	Killed.

* In order to conserve space the dates under "Health Record" have been condensed so that they do not correspond with the dates under "Examination of Urine."

E 186. Born August 3, 1931. The clinical record is given in Table 5.

Postmortem. Both kidneys appeared normal except that the right kidney weighed 20 ounces and the left one 13 ounces. Bladder wall slightly thickened but otherwise normal. Ureters normal in size. Cultures showed nonhemolytic streptococcus and *E. coli* in calyces of both kidneys. Cultures from cortex negative.

Table 5. Observations on Cow E 186.

Examination of Urine		Health Record	
Date	Albumin	Date*	Notes
1931		1931	
Nov. 19	None	Nov. 25	Coccidiosis and pneumonia.
" 26	Present	to 30	
1932		1932	
Feb. 18	Marked	Jan. 16	Off feed.
Mch. 1	Present	" 21	Indigestion.
Apr. 12	"	1933	
May 16	"	Aug. 21	Normal parturition.
June 14	Trace	1934	
July 19	"	Mch. 1	Diarrhea.
Sept. 15	Present	July 30	Normal parturition.
Nov. 14	Trace	1935	
Dec. 13	"	Apr. 21	Mastitis.
		Oct. 3	Suspicious to test for Bang's disease. Removed to clinic
1933			
Feb. 20	Present		to freshen.
		Nov. 5	Normal parturition.
1935		" 18	Acetonemia. Since this cow
May 7	None		was a discard she was
Nov. 11	"		treated in an experimental
" 21	100 mg %		way. She was catheterized
" 22	20 " "		frequently to get urine for
" 25	100 " "		analysis.
" 27	40 " "	" 25	Cystitis.
		1936	
1936		Mch. 18	Killed. Much improved in
Mch. 16	10 " "		condition at time of death.

* In order to conserve space the dates under "Health Record" have been condensed so that they do not correspond with the dates under "Examination of Urine."

The histological sections showed fibrosis which was more severe in the left kidney. Both kidneys showed a distension of the tubules in the medulla similar to that observed in E 165. Both kidneys showed evidence of an acute glomerulonephritis. The glomerular capsules showed little change. Sections from both kidneys showed areas of severe congestion of the capillaries around the tubules in the cortex. This was the only case in which this change was noted.

E 192. Born December 15, 1931. The clinical record is given in Table 6.

Postmortem. Owing to the recto-vaginal fistula the vagina contained quantities of feces. The bladder wall was much thickened. The mucous membrane was reddened and carried small patches of exudate. The right kidney weighed 13 ounces and the left one 17 ounces. The papillae of both kidneys were much

darker than normal and the calyces contained a small amount of exudate. The medullary tissue of the right kidney was somewhat thinner than normal. The cultures from both kidneys showed *Staphylococcus aureus* and a nonhemolytic streptococcus.

Table 6. Observations on Cow E 192.

Examination of Urine		Health Record	
Date	Albumin	Date*	Notes
1932		1932	
Mch. 30	Trace	Jan. 20	Diarrhea.
Apr. 29	Present	to	
May 30	Marked	Jan. 30	
July 5	Present	Apr. 15	Indigestion. Feces dry. Temperature 105.2.
Aug. 1	Trace		
Oct. 3	Present	May 30	Urinating rather frequently.
" 31	Marked	June 20	Off feed.
Dec. 6	Present	to	
1933		June 26	
Jan. 3	"	1933	
Feb. 16	"	Feb. 18	Coccidiosis.
Mch. 14	"	to	
Apr. 6	"	Feb. 28	
May 3	"	1934	
" 5	"	July 19	Difficult parturition. Necessary to cut vagina.
July 5	"		
Aug. 2	Trace	1935	
Oct. 3	None	Apr. 27	Mastitis.
Nov. 7	Trace	July 15	Large recto–vaginal fistula found.
Dec. 5	Present		
1935		Oct. 31	Killed. In poor condition at time of death.
May 15	5 mgm %		
July 15	None		
Oct. 15	5 mgm %		
" 21	5 " "		

* In order to conserve space the dates under "Health Record" have been condensed so that they do not correspond with the dates under "Examination of Urine."

The most marked microscopic changes were in the pelvis where numerous purulent foci were found underneath the epithelium of the calyx. The tubules of the pelvis showed much degeneration and desquamation of epithelium. There was considerable edema and some connective tissue formation between the tubules. The cortex showed a cloudy swelling of most of the tubular epithelium, some cellular infiltration into the glomeruli, and connective tissue formation in practically all the glomerular capsules. The changes found in these kidneys were indicative of an ascending infection.

E 193. Born December 21, 1931. The clinical record is given in Table 7.

Postmortem. Left kidney. See Figure 2. Weight 14 ounces. The capsule was thickened and adherent over most of the kidney. Nearly one half of the lobules were atrophied and presented a roughened, uneven surface. One of these lobules was cystic and the remainder contained soft, friable, grayish-yellow

Table 7. Observations on Cow E 193.

Examination of Urine		Health Record	
Date	Albumin	Date*	Notes
1932		1932	
Mch. 30	Trace	Jan. 15	Scours.
Apr. 29	"	to	
May 30	Present	Jan. 30	
July 5	None	May 30	Urinating frequently.
Aug. 1	"	1933	
Oct. 3	"	Feb. 18	Coccidiosis.
" 31	"	to	
Dec. 6	"	Mch. 14	
1933		" 14	Frequent urination.
Jan. 3	"	Apr. 6	Frequent urination.
Feb. 16	Trace	1934	
Mch. 14	Marked	Oct. 14	Normal parturition.
Apr. 6	Present	Dec. 15	Off feed.
May 3	Trace	1935	
June 5	Present	Feb. 4	Off feed.
July 5	"	" 7	Not eating well.
Aug. 2	Trace	" 24	Treated for indigestion.
Nov. 7	Present	Mch. 9	Removed from dairy herd because production low. Used for nurse cow in beef herd.
Dec. 5	Marked		
1934			
Jan. 16	Present		
Feb. 8	Marked	Sept. 10	Normal parturition.
Mch. 14	Present	Nov. 29	Given a dose of salts.
1935		Dec. 2	Reported sick. Had not been eating well for several days. Poor condition.
Dec. 3	50 mgm %		
" 10	15 " "		
1936		" 3	Slight improvement. Still urinating frequently. Stands with back arched.
Feb. 14	20 " "		
" 17	20 " "		
" 24	15 " "	1936	
		June 13	Killed. In fair condition at time of death.

* In order to conserve space the dates under "Health Record" have been condensed so that they do not correspond with the dates under "Examination of Urine."

calculi. In the figure these lobules occupy that part of the kidney below the line. The location of the calculi in relation to renal tissues is shown in Figure 4. It is evident that they have all formed in the calyces of the kidney. In the lobules which contain the larger calculi, pressure atrophy has caused fibrous tissue to replace most of the normal structures of the cortex and medulla. These changes can be seen in Figure 4 on page 105.

Right kidney. See Figure 3. Weight 20 ounces. The capsule was adherent to most of this kidney. Almost all of the lobules presented a roughened and irregular surface. Four small calculi were found in the calyces of this kidney. These calculi were similar to those found in the left kidney. The lobules which did not contain calculi had undergone some fibrosis.

The bladder wall was somewhat thickened. Both ureters appeared normal. The ureter in Figure 2 appears large because the surrounding tissues were not dissected away before it was photographed. No blood nor phosphatic debris

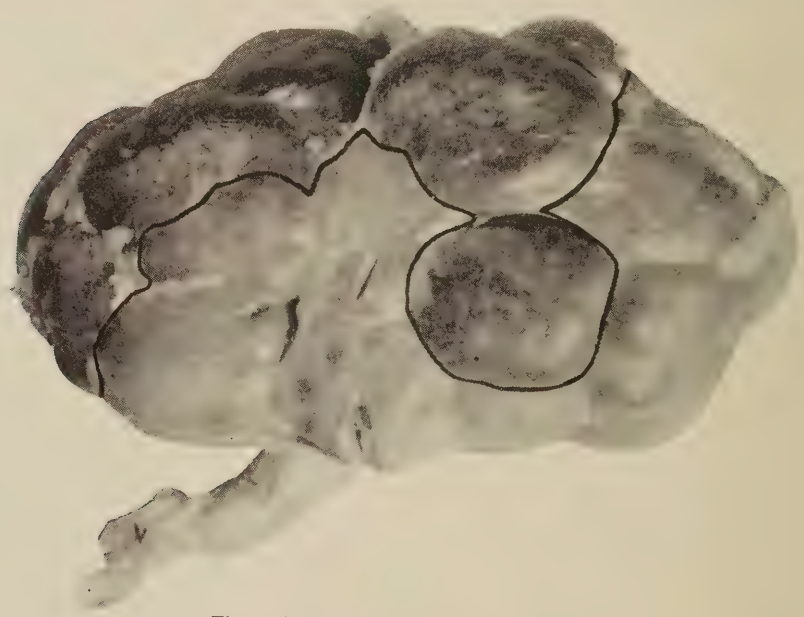

Figure 2. The left kidney from E 193.

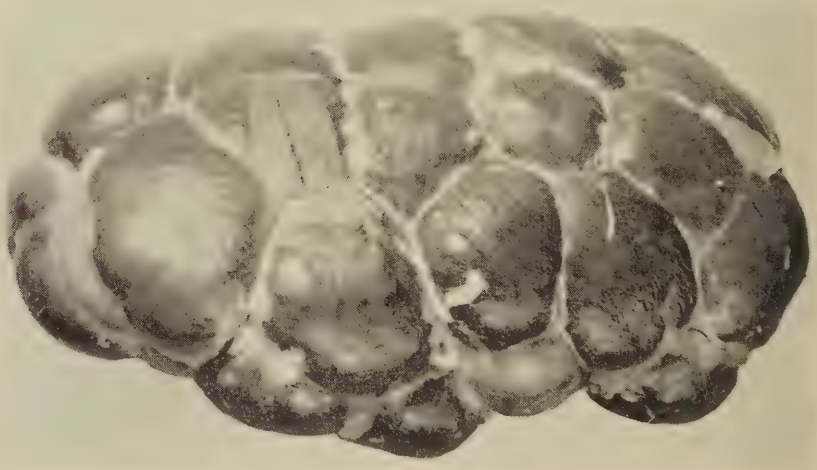

Figure 3. The right kidney from E 193.

were found in the bladder or ureters. The cultures from the calyces and cortex of both kidneys were negative.

A histological study showed a diffuse fibrosis in both kidneys. This was more marked in the lobules which contained the calculi. In these, the calculi had caused a pressure atrophy of the medullary tissue and fibrous tissue had almost entirely replaced the functioning tissues of the cortex.

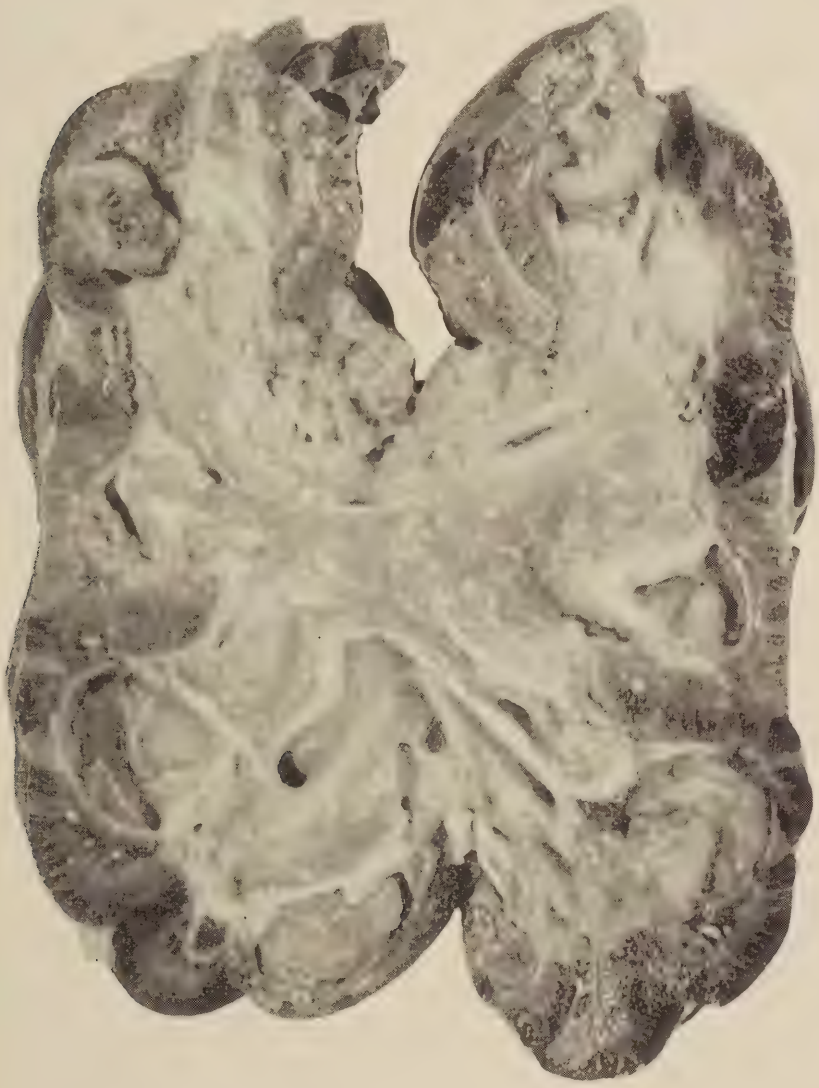

Figure 4. Section of left kidney from E 193 showing calculi and fibrous condition of the kidney.

E 215. Born October 1, 1932. The clinical record is given in Table 8.

Postmortem. The right kidney weighed only 10 ounces. The capsule was adherent over the entire kidney and the surface of the kidney was granular. Many of the lobules contained calculi similar to those found in the kidneys of cow E 193. The left kidney weighed 16 ounces. The lobulation of this kidney was not as apparent as it is normally. This was evidently due to the cortex being somewhat swollen. The capsule was adherent over the entire surface. No calculi were found in this kidney.

The bladder and ureters were apparently normal. A careful examination of them revealed no debris nor evidence of phosphatic material. Cultures from both kidneys revealed a nonhemolytic streptococcus.

The histological changes in these kidneys were similar to those found in E 193 except that the fibrosis was much more severe.

Table 8. Observations on Cow E 215.

Examination of Urine		Health Record	
Date	Albumin	Date*	Notes
1932		1932	
Oct. 31	None	Oct. 11	Scouring.
Dec. 6	Trace	" 31	Scouring.
1933		1933	
Jan. 3	"	Jan. 4	Scouring.
Feb. 16	None	Apr. 1	Constipated, bloated.
Mch. 14	"	May 4	Coccidiosis.
Apr. 6	Marked	1934	
May 3	Present	Jan. 7	Refused feed. Treated for
June 8	Trace		indigestion.
July 10	None	" 30	Treated for indigestion.
Aug. 8	"	Feb. 2	Treated for indigestion.
Oct. 3	Marked	" 20	Treated for indigestion.
Nov. 9	Present	Mch. 14	Treated for indigestion.
Dec. 5	None	" 15	Started use of formin for
1934			kidneys.
Jan. 11	Present	" 27	Bloated. Treated for indi-
Feb. 6	"		gestion.
Mch. 7	Marked	Dec. 19	Diagnosed pregnant.
Apr. 10	Present	1935	
May 8	"	Mch. 12	Aborted.
June 5	"	Apr. 6	Killed at clinic. Has been
July 25	"		gradually losing in condi-
Sept. 20	Marked		tion. She was found down
1935			and was drawn to clinic.
Mch. 12	"		

* In order to conserve space the dates under "Health Record" have been condensed so that they do not correspond with the dates under "Examination of Urine."

Table 9. Cow E 243. Born July 26, 1933.

Date	Albumin	Condition and Treatment
1933		
Oct. 10	Present	
Nov. 14	"	
Dec. 12	Marked	
1934		
Jan. 6	Present	
" 31	—	Treated for indigestion.
Feb. 4	—	Treated for indigestion to February 20. Symptoms of colic.
" 8	Present	
Mch. 9	"	Indigestion.
" 14	"	
Apr. 12	"	
May 10	None	
June 7	Present	
July 23	None	
Sept. 20	Present	
1935		
Apr. 22	10 mg %	
Oct. 22	—	A normal parturition.
" 29	10 mg %	
Dec. 5	10 " "	
" 9	—	Off feed. Lying down most of the time. Seems to stretch when standing. Drinks very little water. Rumen contractions normal. Feces firm. Temperature 101.6. Pulse 62. Respiration 20. Gave only 2 lbs. milk in afternoon.
" 10	50 mg %	Eating better. 15 lbs. milk in morning. Passed about 2 ozs. of clotted blood. Blood and pus cells in urine.
" 11	50 " "	Eating well but not on full feed.
" 17	100 " "	Symptoms of colic in afternoon.
1936		
Jan. 23	—	Lying down stretched out behind most of the time. Kicks at abdomen when standing. Voided about 2 cc. of a dark, cloudy urine. Pulse so fast and weak unable to count it. Temperature 98.4. Catheterized in order to irrigate bladder. Bladder so much in spasm that it was difficult to introduce 300 cc. of a warm physiological saline. Returning fluid contained fragments of phosphatic material. Started treatment with 4 ozs. cod liver oil per day.
" 24	—	Cow shivering during forenoon. Drank only 4 qts. water between 7:00 a. m. and noon. Chewing cud at noon. Pulse 60. Temperature 100.

Table 9 (Continued)

Date	Albumin	Condition and Treatment
Jan. 25	200 mg %	Still shivering. Pulse 60. Temperature 101.0. Catheterized and obtained reddish-brown urine which contained blood cells and fragments of phosphatic material. Washed bladder with physiological saline.
" 28	30 " "	Not as much sediment in urine.
" 30	30 " "	More colicky pains.
Feb. 3	—	Urinating frequently.
" 15	40 mg %	Passed a mass of fibrin in urine 3 inches in diameter and ⅛ inch thick which contained fragments of phosphatic material.
" 16	—	Discontinued cod liver oil.
" 25	50 mg %	Exhibiting symptoms similar to those observed on January 23. Temperature 100.5. Pulse 80 and weak. Respiration 33. Started the use of cod liver oil again.
" 26	15 " "	8:00 a. m. Still in pain. Temperature 100.2. Pulse 90. Respiration 17. 3:00 p. m. In less pain but is kicking at abdomen occasionally. Has urinated and defecated only a small amount. Has taken no water since 8:00 a. m. Voided a liter of urine at 3:30 p. m. Pulse 72. Temperature 101.3.
" 27	15 " "	8:30 a. m. Appears better. Pulse 60. Temperature 100.8. Has taken 5 gal. of water since 3:30 yesterday. Sediment from centrifuged sample shows large amount of streptococcus or staphylococcus and pus cells.
Mch. 4	50 " "	Losing flesh. Not eating well. Producing only 11 lbs. milk per day. Small masses of fibrin and fragments of phosphatic material in urine.
" 6	50 " "	Passed small clot of blood in urine.
" 17	—	Mass of fibrin containing fragments of phosphatic material found behind her in stall.
" 30	15 mg %	
Apr. 1	10 " "	
May 3	—	Off feed to May 5. Production lowered.
June 22	—	Much improved. Cod liver oil dosage decreased to 2 ozs. per day.
Aug. 6	10 mg %	Still improving. Urine still very cloudy with pus cells.
Oct. 13	—	First lactation terminated.

Table 9 (Concluded)

Date	Albumin	Condition and Treatment
Oct. 29	5 mg %	
Dec. 7	5 " "	
" 11	5 " "	Placed on ration made up entirely of oats, corn and bran, which furnishes less protein than her usual ration. She was also given 100 gms. of sodium acid phosphate and 8 gms. of formin per day.
" 12	—	A few shreds of fibrin in urine.
" 14	30 mg %	
" 15	20 " "	
" 16	20 " "	More fibrin in urine, but no evidence of phosphatic material. Pus cells in urine increased. Culture from urine showed a nonhemolytic streptococcus and a few staphylococci.
" 19	20 " "	
" 20	—	Discontinued the treatment because cow is within about 3 weeks of parturition. Resumed her usual ration. It was possible to lower pH of urine from 7.8 to 5.8 but kidney condition showed no improvement.
" 23	10 mg %	
1937		
Jan. 4	15 " "	
" 9	15 " "	
" 14	—	Second calf born. A normal parturition.
" 29	5 mg %	
Feb. 24	10 " "	
Mch. 15	10 " "	
Apr. 15	20 " "	Not eating well.
" 16		Appeared normal.
" 28	10 " "	

E 256. Born November 22, 1933. This animal showed a trace of albumin in her urine at three weeks of age. Tests on January 4 and February 6, 1934, were negative. All samples of urine examined since have shown more or less albumin. Except an intestinal upset during the winter and early spring of 1934, she has had no serious sickness. She has always appeared unthrifty and has always been a non breeder. At present, she is being kept at the clinic as an experimental animal.

The following animals are of interest because of their tendency to show traces of albumin in their urine at frequent intervals since shortly after birth. A consideration of the histories of some of the animals which have been discussed indicates that perhaps these heifers may be the next ones to develop nephritis.

E 326. Born September 7, 1935. This heifer showed traces of albumin in her urine during October, 1935, September, 1936, and again on January 22, 1937. Outside of this, she has been normal in every respect.

E 346. Born February 11, 1936. Twenty-three examinations of this heifer's urine, made between February 21, 1936, and June 18, 1936, all showed albumin in amounts varying from a slight trace up to 40 mg. per 100 cc. This albuminuria disappeared from August 6, 1936, to April 2, 1937, when 5 mg per 100 cc was found. Two more examinations during the month of April showed the same amount of albumin. This calf has been normal thruout the entire period.

E 367. Born October 13, 1936. Examinations of her urine showed 5 mg of albumin per 100 cc on October 28 and 30, 1936, and 10 mg on December 10, 1936, and March 5, 1937. All other examinations were negative. She was treated for scours on October 21 and December 10, 1936. Outside of this, she has appeared normal.

SYMPTOMS

The case reports give a brief account of the symptoms observed in the condition under investigation. In studying them, it should be kept in mind that only four of these animals remained in the herd until the kidney condition brought on death. Some of the cases were disposed of early in the course of the disease because of other troubles. A few of this later group had exhibited only a few attacks of "indigestion" at the time of disposal.

The recurrent attacks of "indigestion" are the most constant symptoms noted in these cases. The attacks varied in intensity from a partial loss of appetite to the severe renal colic shown by E 243. While we cannot be sure that these symptoms of indigestion are due to the kidney condition, the fact remains that they were noted more often in the nephritis cases than in the other animals.

The most pronounced of the other symptoms were seen in the cows in which cystitis developed. These showed the frequent passing of small quantities of bloody urine which contained clots of exudate, pus and fragments of phosphatic material. They all suffered severe colicky pains and lost condition rapidly during these attacks. Marked improvement was noted in the condition of the animals as the cystitis cleared up.

All the advanced cases urinated more frequently than the normal animals. This symptom was more noticeable in the cows suffering with cystitis but was also noted in the other cases. The urine was usually almost colorless and in most cases the specific gravity was low.

The urine from cows with infected kidneys is usually cloudy because of a suspension of pus cells. This type of cloudiness can be easily detected because it does not settle out as rapidly as a suspension of carbonates or phosphates. It is not uncommon to find pus cells still in suspension after the urine has stood over night.

Albuminuria. This study has shown that albumin may occasionally occur in the urine of cattle in which there is no serious involvement of the urinary tract. It is common knowledge that a transitory albuminuria may accompany many febrile diseases. In this work, it has been found accompanying mastitis, metritis, pneumonia, enteritis and coccidiosis.

It is not uncommon to find an occasional animal which, without any apparent cause, shows varying amounts of albumin in the urine for certain periods of time. Sjollema (3) mentions the occasional occurrence of a feeble protein reaction in the urine of normal cattle, seen more often in the autumn while the cows were still on grass. Stewart (4) reports the periodic occurrence of a rather marked albuminuria in sheep. His postmortem findings and a study of the diet of these sheep left him unable to explain the condition satisfactorily. Similar findings have been made in this herd. Several cows and heifers have shown a rather marked albuminuria when there was nothing in their clinical history to explain its appearance. Daily examinations of the urine from these animals often showed that the albuminuria cleared up spontaneously within a few days. Many of these cows have shown no further albumin in their urine.

It will be noted by examining Table 2 that albuminuria was observed early in the life of most of the cows which later developed nephritis. Nine of the eleven cases, with a clinical record complete from birth, began to show it from three months to one year of age. It is difficult to explain this early appearance of a persistent albuminuria. With cows E 142, E 165, E 186, E 192, E 193, and E 215 the initial appearance of albumin was preceded by an attack of either enteritis, indigestion or coccidiosis. A study of the health record of this herd shows, however, that many of the calves and heifers suffered similar attacks with no permanent injury to the kidneys. The clinical record of the rest of these cases offers nothing which might explain the onset of albuminuria.

In this connection, attention should again be called to the rec-

ord of E 346. Albumin was found in her urine ten days after birth. Following this, albumin occurred in traces for a period of four months, after which all tests for albumin were negative for nine months. As far as can be determined, she has been normal in other ways since birth and yet traces of albumin have again appeared in her urine. It is hoped that further study of her case will offer help in explaining this condition.

E 68 offers another interesting case for study in this connection. Unfortunately, no examinations were made of her urine from 1931 thru 1934. It is significant, however, that all samples examined in 1930 and during 1935 and 1936 showed various amounts of albumin. While four cultures of her upper urinary tract were negative, her kidneys showed changes suggesting a chronic nephritis of long standing. The microscopic examination showed a marked chronic glomerulonephritis with considerable hyalin in the glomerular tufts, a fibrous thickening of practically all Bowman's capsules, large areas of round-cell infiltration and fibrosis in the cortex, and a profuse degeneration of the tubular epithelium. In spite of these findings, a study of her clinical history and of her daily milk weights for five lactations gives no indication of any sickness.

The records show that all the cases except E 29 have shown albuminuria more or less regularly from early life, up to the time of death or disposal. In some of them the amount of albumin was increased as a result of some infectious process. Infection was found in six of the eight urinary tracts which were cultured. The two which were negative to culture showed changes which indicated that they might have been infected at one time or another. It is impossible to determine the source of the infection which has affected the kidneys. The possibility has been considered that the use of the catheter may be blamed for some of it. While it would be unwise to say that this has not happened, the fact remains that the catheter was used on Jersey and Holstein alike and that none of the Holsteins have shown nephritis. In three of the cases, it was necessary to cut the vagina in order to deliver the first calf because of an abnormality of the vaginal wall. While this may have been the direct cause of the infection in the urinary tract, all these cows had shown albuminuria for some time before the operation.

The early appearance of persistent albuminuria which tends to increase in severity, the frequent occurrence of symptoms of nephritis following infectious conditions, and the postmortem findings in these cases all suggest that this condition may have started as a sort of functional albuminuria or nephrosis which gradually weakened the kidneys to the point where they offered little resistance to infection. Such a functional albuminuria is observed occasionally in human medicine. Burden (5), in an analysis of 58 cases of what he terms an idiopathic or persistent functional albuminuria, suggests that this condition may lead to further damage to the urinary tract. In this connection, he states, "We cannot help wondering whether these repeated functional disturbances may not in time lead to organic changes in the kidney, heart and blood vessels." A study of the occurrence of albuminuria and nephritis in respect to the breeds affected adds some weight to this theory. Table 2 shows that, out of the sixty animals which have shown albuminuria more than once, 80 percent were Jerseys. None of the nine Holsteins showed the persistent type of albuminuria. An analysis of all the cows examined during the past six years is presented in Table 10.

Table 10. A synopsis of the records of all animals examined from October 29, 1930, to March 5, 1937.

	Jersey	Holstein	Guernsey
Number examined	103	45	8
Percentage showing no albuminuria	30	53	50
Percentage showing albuminuria one or more times	70*	47	50
Number definitely diagnosed as nephritis	13	0	0

* Including Jersey-Guernsey crossbred.

This shows that, while nearly half of the Holsteins examined showed albumin in their urine at one time or another, not one of them developed nephritis. Seventy percent of the Jerseys examined had albumin in their urine and nephritis was diagnosed in thirteen of these. When we consider that the cows of both these breeds were maintained in the same manner as regards feeding, management and treatment of diseases, these findings are rather striking. It is barely possible that we are working with a strain of Jerseys which are more susceptible to various conditions which may affect the kidneys.

A study of the pedigrees shows that the twelve Jersey females which showed albuminuria followed by nephritis were quite closely related. Nine of the twelve were by one sire. Six were as much as 31 percent related to a sire 3 to 5 generations removed. Three others had a relationship coefficient of 21 to 25 percent to this same sire, and the remaining three from 9 to 13 percent. Nine of the twelve females were definitely inbred, having coefficients of inbreeding ranging from 1 to 10 percent. Two of the three having inbreeding coefficients of 10 percent were full sisters and the third carried 75 percent of the same blood.

THE CALCULI

The calculi which were found in the kidneys of E 193 are shown in Figure 5. Similar calculi were found in the calyces of the kidneys of E 215. No calculi nor phosphatic material were found in the ureters or bladders of these cows. Granular phosphatic material, which appeared like fragments from this type of calculus, was found at various times in the urine from E 176 and E 243. While exudate mixed with some of this granular material was found in the calyces of the kidney and in the bladder of E 176, there was no evidence of the formation of calculi anywhere in the urinary tract.

Buckner and Good (6) reported an analysis of what was evidently this same type of calculus, from the kidneys and bladder of a young Hereford bull which was reared on the Experiment Station Farm. They found them to be composed mainly of magnesium phosphate with a little calcium phosphate.

A preliminary examination of the calculi from E 193 showed them to be phosphatic with a small amount of fibrin and a slight trace of carbonate. A more complete analysis, made by the Chemistry Department, gave the following results:

Analysis of the material after drying at 100° C.

	Percent
Total nitrogen	1.67
Ammonia nitrogen	0.47
Cystine	none
Inorganic sulfate	trace
Total ash	74.8
Phosphorus	18.05
Magnesium	18.02
Calcium	1.22

These findings suggest that the calculi were composed largely of magnesium phosphate and magnesium ammonium phosphate, with a small amount of tricalcium phosphate, and about 20 percent of organic matter.

Figure 5. The calculi from the kidneys of E 193. Two-thirds natural size.

There are numerous references in the literature regarding the experimental production of phosphatic urinary calculi in rats by feeding a diet which is low in vitamin A. Higgins (7) reports the disappearance of these experimentally produced calculi from the urinary tract of the rats following the feeding of cod liver oil and an acid-producing diet.

While it is doubtful if any of these cows have suffered from a vitamin A deficiency, it was decided to try the effect of cod liver oil on E 243 after it was discovered that she was passing phosphatic material in her urine. The oil was given at the rate of 4 ounces per day from January 23 to June 22, 1936. Since that date she has had 2 ounces per day. Her case report and the record of her milk production both indicate that she has shown much improvement since the treatment was started. She is not completely recovered, however. A culture of her urine on December 16, 1936, showed a

nonhemolytic streptococcus and a staphylococcus. Her urine still shows many pus cells and is carrying a small amount of albumin. Except the administration of cod liver oil, this cow is being handled the same as the rest of the herd.

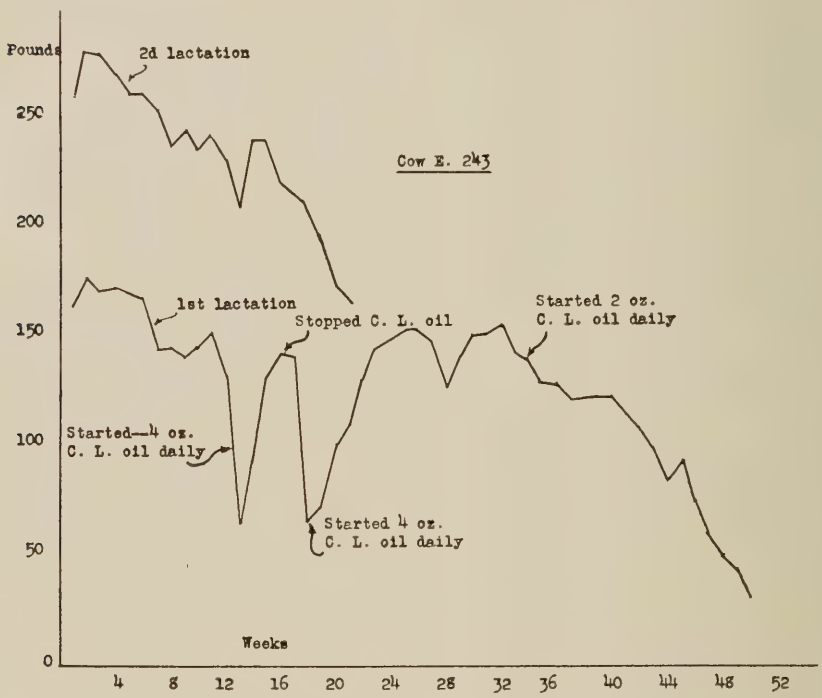

Figure 6. Production of milk, cow E 243.

The record of this cow's weekly production of milk is given in Figure 6. Her first lactation shows the wide fluctuations in production which were noted in the more severe cases of nephritis. It is doubtful if stopping the cod liver oil was in any way responsible for the second severe slump in production in her first lactation. Her second lactation shows a marked improvement over the first one with the weekly variation in milk production much less.

EXAMINATION OF THE URINE

The periodic examination of the urine was a valuable aid in dealing with this outbreak of nephritis. It is not a difficult procedure. By using the method described earlier in this bulletin it is

possible to collect the samples rather rapidly. If any difficulty is experienced in using this method, it will be well to try it first on the young calves. It is very easy to make them urinate in this way. Where it does not work with the heifers and older cows our practice has been to fasten them in the stanchions and wait for them to urinate, catching the samples with the long-handled dipper.

Allowing the samples of urine to stand over night in an ice box before testing them gives the phosphates, carbonates and fecal matter a chance to settle out. By carefully examining these samples in the morning suspensions of pus cells may be detected. If the sediment in the bottom of the bottle is not disturbed, a clear 10 cc sample may usually be drawn off the top with a pipette. If a clear sample cannot be obtained by this method the urine should be filtered. The sample may be tested for albumin by the heat and acetic acid method. This consists in heating the urine to boiling in a test tube and then adding a dilute acetic acid until the sample is acid. Where phosphates and carbonates are present it is necessary to contine the addition of acid until they are all dissolved. If the original sample was clear, any cloudiness noted after this treatment indicates the presence of albumin. It is a good plan, however, to examine other samples from positive cases in order to make sure of the diagnosis. Our experience has shown that the albuminuria may disappear after a few days. This examination of the urine has been of sufficient help in dealing with this condition to make us feel that it is an important procedure when working with nephritis in a valuable herd.

Our method of dealing with it was to diagnose the condition by the appearance of albuminuria and chronic indigestion and to dispose of cows that showed these symptoms as soon as their production did not warrant keeping them. All efforts to treat these cases with urinary disinfectants proved unsuccessful. At present, E 243 is the only case of nephritis left in the herd.

SUMMARY

1. Samples of urine from the cows of the Kentucky Experiment Station dairy herd were examined for albumin for a period of over six years. During this time 103 Jerseys, 45 Holsteins, and 8 Guernseys were under observation.

2. Some of the Jerseys showed albuminuria more or less regularly since calfhood and 13 of them finally developed nephritis. While some animals of the other breeds showed albumin in the urine, it did not appear regularly and they developed no nephritis.

3. The kidneys from these nephritis cases showed a wide variety of lesions and the cultures showed either a colon organism, a non-hemolytic streptococcus, a staphylococcus or a combination of these organisms.

4. The history of these cases, the variety of lesions found and the different types of organisms occurring in the urinary tract, all indicate that this nephritis was not caused by a specific infection.

5. The possibility is suggested that we are working with a strain of Jerseys which is susceptible to conditions affecting the urinary tract. A study of the pedigree of these afflicted animals strengthens this argument.

6. A favorable report is given regarding the use of cod liver oil on one case of nephritis.

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